Art, Science

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Abstract: The author questions the origin of the artist/scientist split, manifest in the structure of our higher educational institutions, and comments on the many existing and potential contributions of art to science, especially computer graphics and visualization. It is the author's view that the distinction between and separation of art and science is artificial and increasingly anachronistic, and that education is both a problem and a solution.

**" 'Truth,' as defined by Alfred North Whitehead, 'is the conformation of Appearance to Reality.' What makes any set of bedrock truths slippery is that every age and every culture defines this conformation in its own way. When the time comes to change a paradigm - to renounce one bedrock truth and adopt another-the artist and physicist are most likely to be in the forefront."

Leonard Shlain, Art and Physics, 1991

Leonardo da Vinci as a Role Model

The link between visual art and science has historically been very close. We know this is true because we have evidence in the very existence of works of art which required technological and scientific advances to produce them in the first place. Over time, the ideal of the artist-scientist as an integrated, educated individual, the "universal man" of the Renaissance, became synonymous with Leonardo da Vinci. He represents the achievement of the union between art and science, and as such has become a role model for subsequent generations of artists and scientists. Today, he has been elevated to almost mythic proportions, with even the innovative journal, Leonardo, of the International Society for the Arts, Sciences, and Technology, named after him. Despite his genius and the timelessness of his contributions, Leonardo has somehow become a decontextualized, isolated genius, a largely impossible and unsupported role model for contemporary students of art and science. All of us have constructed a personal mythology about him based on fragmentary information from the past, none of which result in a complete, truthful representation of the man. Further, Leonard Shlain, in Art and Physics has pointed out that it is primarily art students who study his work and rarely science students. The effect is that the ideal that Leonardo represents, which is supposedly embraced by our universities and institutions of higher learning, is really not agreed upon by the art and science communities, and thus is not commonly shared between them. Consequently, Leonardo has become a practically impossible role model for anyone to emulate.

The term "university" derives from "universalism," the Renaissance philosophy that embraced "man as the measure of all things," and the requirement to study all disciplines within a unity of knowledge and achievement of wisdom. While I believe that most universities aspire to the potential of collective wisdom and broad based intellectual growth by collecting diverse departments within a single system or structure, the size of the institutions today and the

pressures upon individuals within most departments has actually led to isolation rather than interdisciplinary communication and collaboration. As a result, most educational institutions carry on the spirit of universalism in name only. As a professor at a prestigious research university offered, “the opposite of diversity is university,” and since diversity and specialization is in fact what our universities have come to promote, it seems that we ought to call them “diversities” instead of “universities.” I believe that cultural and intellectual diversity is integral to the health of educational institutions, but that the decontextualized isolation associated with specialization can be stifling and destructive. Specialization, despite its profound contributions to our collective body of knowledge, has led to a breakdown in communication between disciplines, especially art and science. And without communication, there can be little or no understanding or shared information. Thus, universalism, the ideal that Leonardo represents, has become an anachronism, in that it is in contradiction to the values currently espoused within our conventional educational structures. Moreover, the separation of art and science education and the accompanying human communities allows for stereotypes about the two groups to thrive.

Photography and the Art/Science Split

One can observe that a breakdown in direct communication (and consequently often mutual respect) between art and science deepened at about the time of the invention of photography 150 years ago. While painters were freed by the camera’s invention from serving primarily as recorders of history to explorers of new forms of visual representation of a wide range of alternative and abstract ideas, science found photography useful as an observing tool. Cries from the art community about the subjectivity of truth, even with a camera, (a photographer composes and edits images, and can alter the photograph in the darkroom) served more to separate photography from art than to engage the scientific community in intellectual discussions of ethics and visual representation. It is apparent that because science employed photography as a tool, and because many artists moved away from the visual paradigm of classical perspective and optical realism, the gap in communication between science and art widened. This gap is just now beginning to be bridged, as the graphics computer, also a descendant of classical perspective and photography, is quickly developing in the hands of both artists and scientists. Artists are infusing contemporary visual and conceptual paradigms and scientists are working with contemporary natural and computational paradigms. And at the base of much of this work are fundamental philosophical attitudes which date from the Middle Ages and before: the mind-body split and its descendant, the material-spiritual split of the Renaissance, which has continued to the present and takes its form in the stereotypes of the artist and the scientist. These philosophical issues have not been updated nor resolved in light of our contemporary collective computer-based community of artists and scientists. I feel that philosophical issues such as these are already a subtext to collaborations between the two groups and will likely be hotly debated as we re-construct our identities as artists and scientists.

Art History

Despite the current movement towards integrating paradigms for thinking about images (ultimately made up of light, space, and time) from both the arts and the sciences, there is a great deal of “catch up” required on both sides. And while the search for optical realism in computer graphics has led to important developments such as ray tracing and virtual reality, it is my

opinion that as a form of visual representation, optical realism based on classical perspective alone is not the ultimate, end goal of computer graphics. It is important to remember that while perspective and photography are related through the common ancestor of the camera obscura, the light sensitive surface of film is itself directly related to the structure of the retina and Helmholz's theory of tri-variance. (Cathode ray tubes use the theory of tri-variance, also.) Over 100 years ago, this paradigm for thinking about light and images was paralleled in the work of the impressionist painters, including Claude Monet. Leonard Shlain, in Art and Physics, calls Monet the first relativistic painter, in that his paintings are about change in light as affected by change in time. Painters and photographers saw that classical perspective is only one, albeit powerful, element of the perceived image, and that the "big picture" includes perspective but is not limited to it. It concerns new ideas about the structure of the image: light, space, time, perception, perceptual apparatus, and interpretation of data in its multiple and kinetic forms. And today, "realism" and "truth" do not just mean dispassionate observation of the surface qualities of a visual scene. It means perceiving a sense of reality, being aware of the subjectivity of truth, the existence of multiple and perhaps contradicting truths, understanding the context of the observed and the effect of the observer upon the observed. We all know that much more than what we can see is real, made tangible with remote sensing devices that extend the dynamic and temporal range of our sensory perception to include such things as heat waves and data from distant stars and distant times. From contemporary chaos theory, we understand that disorder is a form of order, and that small changes in a system can cause large scale effects. In short, it simply seems inappropriate to use a model of realism from the 15th century to represent 20th century realities.

Fifteenth century, western, classical perspective is based on a static, single, measurable view of the world, which does not by itself deal with the problem of concurrent and constructed realities, movement, or contemporary concepts of time, light, space, order and chaos. Impressionism and Cubism, for example, dealt with color (light) and movement (time). Cubism mapped time to space, that is 4-dimensions (x, y, z, and time) to 2-dimensions (x and y), and dealt with issues of relativity (what you can measure and therefore represent visually depends on your point of view, and the same scene can be viewed from many points of view, simultaneously). Motion picture film also does this, but in a different way. It maps 4-dimensions (x, y, z and time) to 3-dimensions (x, y and time). It exists as a linear, graphical sheet of sequential images, but is usually experienced as a "single" transitory, 2-dimensional image. The reduction of dimensions from 4 to 3 or from 4 to 2 thereby frees up a dimension or two for the representation of other information. Since virtual reality systems deliver five dimensions (2 -x, y, z views, and time), it is possible to transmit a great deal of information beyond that of traditional perspective images by using clever strategies for embedding data, many of which were laid out over the past century by visual artists, including painters, photographers, stereographers, filmmakers and others. Recent concerns about howwe know what we know, especially in relation to media, the ultimate mythmaker and source of mass, "ersatz" primary experience, should be of concern to all who create computer images, given the computer's ability to undetectably alter photographic images. How does the representation of reality affect our experience of it? Since what we see is based on what we know and how we see, the way we construct our world view defines what we can see. Our world view is shaped by our mental strategies for negotiating the world of light, space, and time. Therefore, it is likely that people with different backgrounds see differently. But each world view is "true" and "real" for each person. Moreover, given that all representation is an

illusion, then all images are at best, potential truths. Given this dilemma, our images lose objectivity and become myths.

Film History

Clearly, it is obvious that the universe is not static, and that movement and dynamism are integral to contemporary models of nature and reality. The development of motion picture film came a century ago, after artists invented photography and discovered the phenomenon of persistence of vision. Today, the very act of incorporating animation into scientific visualization pays unspoken homage to art and artists, and draws upon a rich heritage shaped almost entirely by them. These people include Oskar Fischinger, Norman McLaren, and others whose work has become a permanent part of film language and technique. Film artists know this history and build upon it. Working with computers, contemporary experimental animators are at the cutting edge of understanding the complex relationships between information, visual representation, and movement, and therefore have a great deal to contribute to the scientific community's work in visualization of dynamical systems. Scientists working in visualization can benefit from a study of film history just as filmmakers can. Both groups can benefit from working in proximity to each other on their own research as well as on collaborative projects.

Virtual Reality and other Virtual Arts

Other movements in art are related to computers and VR, including conceptual and performance art, which emphasizes the idea and the experience rather than the object, and at times employ algorithmic or rule based processes and audience participation. This "dematerialization" of art is part of a breakdown of the "art triad," where a blurring of distinctions between the artist, the art object and the audience evolved since the end of World War II. This trend helped develop conceptual and performance art of the 1960's through the 1990's, and influenced much contemporary computer art. Virtual reality, especially, dematerializes the object and invites audience participation, as does interactive work making use of the Internet and other telecommunications media. It is clear that much can be gained by the technical and scientific communities from study of the "virtual arts."

Multi-culturalism and Global Issues

The extension of visual language to new forms of art includes multi-culturalism. As tele-communications and computer technology develops and integrates into other cultures around the globe, it behooves us all to respect the traditions of other cultures when integrating forms of representation of those cultures into new technology. If we hope to provide entry for diverse cultures into our visual communications language and technology, we must be aware of the potentials and limitations of our own language and extend it to include others. Since sci-vi and computer graphics are a potentially global form of information representation and transmission that requires learning and development of a visual vocabulary, they should be very sensitive to cultural issues of representation. Their strength will come through their integrity, which arises from a fundamental respect for others together with sound visual language and science skills.

Cyberspace

Given cyberspace as a common work environment for artists and scientists, it is not surprising that graphics computer scientists today are facing many of the same problems that photographers and artists encountered long ago, as well as current issues from the respective communities. Many of these problems seem eerily familiar, especially those regarding truth, the "construction of reality" (however differently interpreted) and the manipulated, duplicated, and dematerialized image. And while the century old hostility from the art community towards photography seems to have been transferred to computers, largely because of the computer's association with science and science's general lack of participation in the critical dialog regarding the image, this too is breaking down. The scientific community is beginning to educate itself about images and the arts, and engage itself in a dialog with it. And the broader arts community, though skeptical and critical, is embracing computer technology more readily than before.

Reunion?

While there is a great hope for a renewed art/science union facilitated by computers, there is still the very real problem of changing the deeply rooted, fundamental attitudes discussed above, which have been perpetuated through generations of official separation, effectively an apartheid of the intellect. In particular, the range and scope of the artist's work has generally not been seriously studied and integrated into science education. Today, when the scientific community is grappling with problems of visual representation of complex, multi-dimensional problems, there is a great deal that this community can learn from the work of artists engaged in similar activity. For many thousands of years, artists have been working with problems of representation of complex, abstract information, transforming itself through time and context, and resulting in what today are rich visual languages. Most artists know the history of art and can easily see how the evolution of computer graphics parallels and transforms it. It is clear that the study of art history (including photography and film) should be a requirement for anyone interested in art and science, including computer graphics.

Artists have always engaged in a verbal and visual dialog with their time, transcending disciplines to include the sciences in the expansive reach of their intellectual exploration. Their work, ideas and discoveries have benefitted the sciences dramatically. However, the historical impact of visual art on science and technology has been anecdotal, at best. It has not been properly documented and communicated to science or art students, and this lack of information most often serves to perpetuate poor attitudes towards each other. It is time that the art community be recognized with dignity and support for their role in the development of science and technology. Again, photography is an excellent example. How many scientists know that two artists invented it? Take a closer look at the artist's role in the development of film, video and computer animation. A parallel can be made to the artists role in the development of spoken and written language. Just imagine what the English language would be like if only scientists and engineers had developed it, without influence of the likes of William Shakespeare or James Joyce!

Now that scientists are relying increasingly on visual communication, and artists are working more and more with computers, there is a common meeting place to transfer information, ideas

and knowledge. Visual problems are ultimately the same across disciplines, and scientists have much to gain from communication with artists, given their deep understanding of perception, communication and visual language. As Professor Carver Mead of the California Institute of Technology remarked, “New fields arise from the synthesis of other fields.” Computer graphics is a new field made up of art and science, and both fields must be treated with respect. By bringing the best minds of art and science together, there can be a powerful synthesis of knowledge, the repository being not only the people but the collective memory in the common medium of computers. Through networking and telecommunications, the collective information is quickly disseminated and integrated into a wider population.

Multi-dimensional Education and Summary

While individual artists, scientists, and institutions have made heroic efforts in initiating interdisciplinary communication, and serve as leaders and role models, a large scale effort to support and promote interdisciplinary communication is still necessary. A multi-layered educational approach, not only formal, spanning one-to-one personal collaborations and communication to formal institutional education and research (elementary through post-doctoral, public and private), should be actively and seriously promoted and supported. The scope of content should be the full range of common issues and problems, and include art and media history, studio courses which engage the science student in creative work, and reflective, thinking courses that probe and question philosophical issues associated with new, uncharted territories of human thought in relation to computers. Similarly, crossover artists should study mathematics and technology. The computer graphics field, including scientific visualization should be increasingly comprised of artists and scientists with a common educational foundation, resulting in mutual communication, appreciation and respect, as well as the essential transfer of ideas, knowledge and information. Inevitably, and more importantly, new models of the integrated artist-scientist will emerge, becoming contemporary role models, as contemporary as Leonardo was in his time, in a quickly changing world. Universities and other educational structures, like software, must be continually updated. Finally, formal education will have to be supplemented with life-long self-education through exposure to art and science exhibits, publications, performances and events that serve to stimulate and inform the artist-scientist about new ideas, problems and solutions in our complex and dynamic world.

Afterword

An adage from the 1960’s echoes through recent decades and is relevant today: “you create your own reality”; So, let us aspire to making our collective reality, including our schools and other human communities, as thoughtful and intelligent as possible as we gear up to create the first electronically mediated, networked millennium change.